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Money-Income Causality: Further Empirical Evidence

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I. Introduction

Theoretical discussion involving the relationship between stock of money and nominal income has dominated the field of monetary economics for many years. Within this relationship the question of exogeneity of money is critical. Theoretically, two major views concerning this subject can be readily identified: the monetarist view (based on the postulates of the Quantity Theory of Money) and the Keynesian or income expenditure view[1]. Proponents of the endogeneity approach claim that since the stock of money is endogeneously determined, the causal flow from money to nominal income cannot be established. Consequently, any attempt to control the stock of money is meaningless[2]. The supporters of this view assert that fluctuations of monetary growth result primarily from the behavior of the public and commercial banks and not from the actions of the Federal Reserve authorities[3]. Consequently, the stock of money is demand determined. The origins of this view can be traced to the Real Bills Doctrine of the 18th century and the commercial loan theory[4]. The monetarists, on the other hand, not only assert that the nominal stock of money is exogeneously determined, but that there exists a direct causal flow from money to money income[5]. Changes in the stock of money dominate movements in money income[6]. Some monetarists allow for a feedback from income to money supply, but even then the monetary changes are considered the major factors determining the stock of money[7].

The resolution of the above theoretical dispute involves econometric testing of causality of the money income relationship. In this respect, the works of Granger (1969) and Sims (1972) undoubtedly played a major role. Recent work in this area was carried out by Guilkey and Salemi

(1982), Geweke, Meese, and Dent (1983), and Hsiao (1981, 1982), among others. Both the earlier work by Sims and the recent contributions of Guilkey and Salemi relied on an arbitrary choice of the lag structure in causality testing. Hsiao (1981) suggested that the arbitrariness in choosing appropriate lags can be eliminated by using the final prediction error (FPE) procedure.

The purpose of our study is to find further empirical evidence concerning the money income causal relationship and to establish which measure of money is most appropriate for empirical model developing and testing. The procedures developed by Guilkey and Salemi are used in the initial causality testing. The monetary base is added as an additional test variable. The causality results obtained through this procedure are compared with the causality test results involving the FPE procedure. The FPE procedure enables us to not only ascertain the validity of the previously obtained causality test results, but also to establish the appropriate lag specification of each variable. This procedure can significantly strengthen the statistical validity of causality tests.

Our paper is divided into four major sections. The first summarizes major theoretical and econometric issues involved in the causality testing. The methods and results of the first category (arbitrary lag selection) of the Granger causality tests are outlined in the following section. The FPE estimation procedures and their results are presented thereafter. Overall conclusions are presented in the final section of our study.

II. Causality Test Issues

Theoretical discussions involving the causality issue in the money-income relationship must also address the question of which measure of the money stock is appropriate. It can conceivably be argued that there exist four basic measures of money stock: monetary base, M_1, M_2, and M_3. The theoretical discussion of exogeneity of the money stock may well depend, to a large extent, on which definition is chosen. Economic theory suggests that only the monetary base or high-powered money is truly exogeneous, since both of its components, currency and reserves, are directly under the control of the Fed[8]. M_1, on the other hand, is defined as m.B, where B is the monetary base and m is the money multiplier. Several components of the money multiplier can be considered endogenous[9]. Similar arguments apply to M_2 and M_3. Therefore, the causality tests should include the monetary base as well as or even more so than M_1 and M_2.

Causality tests carried out by Hsiao (1981) include only M_1 and M_2 as the test variables. Sims includes M_1 and monetary base, but his causality tests consist of regressing the log of GNP on future and lagged log M_1 and base[10]. Guilkey and Salemi present their versions of three causality tests: the Granger test, the Sims test, and the modified Sims test[11]. The main purpose of their study is to identify which test is best for the causal ordering of time-series in the Granger (1969) sense. Guilkey and Salemi find the Granger and the modified Sims test (as developed by Geweke et al.) superior to the Sims test but recommend the Granger test because of its computational simplicity and a lesser loss of degrees of freedom. Hsiao (1981) suggests that in econometric hypothesis testing the order of lags has to be correctly specified in order to avoid imposing spurious or false restrictions. His step-wise procedure of determining the minimum final prediction error (FPE) not only solves the problem of arbitrary lag selection but also provides a powerful causality test method[12]. The FPE procedure is used to test causality between nominal GNP, M_1, and M_2. Hsiao finds M_2 to be a more appropriate definition of money than M_1 because the relationship between M_2 and income is more stable than the relationship between M_1 and income. In terms of causality, Hsiao finds changes in M_1 to be a consequence as well as a cause of changes in income. M_2, on the other hand, plays a largely independent role in determining money income[13].

With the exception of the Sims work, the causality studies attempt to establish a causal relationship between nominal income approximated by nominal GNP and money measured either by M_1 or M_2. No attempt is made to include the monetary base as a money test variable. This omission can be regarded as rendering the above described causality tests somewhat incomplete. Since economic theory suggests that the monetary base can be viewed more exogenous than either M_1 and M_2, a strong case can be made for including the monetary base in causality tests. In addition, both the Sims (1972) and the Guilkey and Salemi (1982) test procedures rely on the arbitrary lag determination in causality testing. As such, there exists a possibility of selecting incorrect lag structure. Since the selection of the lag structure can have profound implication to the causality test results, correct model identification becomes critical.[14]

III. Causality Test Results

The definition of causality used in our study is that given by Granger (1969). In the Granger sense, X_2 causes X_1 if and only if $X_1(t)$ is better predicted by employing the past history of X_2 than by not doing so. Here, the past of X_1 is used in either case. Conseqently, if X_2 cause X_1 and X_1 does not cause X_2, then unidirectional causality is established from X_2 to X_1. In cases where it is found that X_2 does not cause X_1 and X_1 does not cause X_2, then X_1 and X_2 are either statistically independent or related contemporaneously. Finally, if X_2 causes X_1 and X_1 causes X_2, then the feedback exists between X_1 and X_2.

The Granger test procedure as outlined by Guilkey and Salemi (1982) is used in the initial stages of estimation. There are two main reasons for selecting this procedure. The procedure is superior to other test procedures (see Guilkey and Salemi, p. 679). Second, by exactly duplicating the test procedure, the updated results can be readily compared with the original results, and economic inferences can be made.

The test itself involves an OLS estimation of the following equation:

$$X_{1(t)} = \sum_{j=1}^{J} ajX_{1(t-j)} + \sum_{j=1}^{J} bjX_{2(t-j)} + \alpha + \beta \, . \, t + U_t \qquad (1)$$

Here X_1 and X_2 are nominal income and the money stock, and t is a time-trend variable. The test of the null hypothesis that X_2 does not cause X_1 is the test that $bj = 0$ for $j = 1, 2, 3, \ldots, J$. Problems of serial correlation do not arise in estimating equation (1) because of the inclusion of lagged dependent variables.

Equation (1) is estimated in both constrained and unconstrained forms. The test of no causality is based on the following statistic:

$$F = \frac{(SEE_c - SEE_u)/J}{SEE_u/[T - (2J + 2)]} \qquad (2)$$

Here SEE_u and SEE_c are the residual sum of squares from the unconstrained and constrained regressions. To test the hypothesis that X_1 does not cause X_2, the F statistic is estimated while the roles of X_1 and X_2 are reversed.

In this procedure, the choice of J is arbitrary. Our selection of J is 6, 8, and 12.

Equation (1) is estimated in the log form. Seasonally adjusted data for nominal GNP, M_1, M_2, and monetary base are used[15]. The sample period under consideration is 1959-I to 1984-II. The results of our estimations are reported in Table 1 below. All the tests are carried out at the 5 percent and the 1 percent levels of significance.

Causality tests involving M_1 yield mixed results. At the 5 percent level of significance we find that M_1 does not Granger cause GNP, and GNP causes M_1. These results hold for j = 6 and j = 8. The same result holds at the 1 percent level of significance for j = 6. However, for j = 8, we find X_1 and X_2 to be statistically independent at the 1 percent level of significance. When j = 12, then M_1 is endogenous at both the 5 and the 1 percent levels of significance.

Choosing j = 6, we find M_2 to be exogeous at the 1 percent level of significance. However, the feedback is established between GNP and M_2 at the 5 percent level of significance. With j = 8, the results are the same at the 5 percent level of significance, but M_2 is endogenous at the 1 percent level of significance. Finally, setting j = 12, we find M_2 to be endogenous at the 5 percent level of significance. M_2 and GNP are statistically independent at the 1 percent significance level.

The results for the monetary base are much more conclusive than those for M_1 and M_2. The monetary base is clearly exogenous in the Granger sense at both levels of significance with j = 6, and j = 8. When j = 12, the monetary base and the GNP are statistically independent.

TABLE 1

Granger Causality Test Results for Nominal GNP (X_1), M_1, M_2, and Monetary Base for 5% and 1% Levels of Significance

Hypothesis

X_2 does not Granger cause X_1

$$X_{1(t)} = \sum_{j=1}^{j} a_j X_{1(t-j)} + \sum_{j=1}^{j} b_j X_{2(t-j)}$$

$H_o : b_j = 0 \quad j = 1, 2, \ldots, j$

X_1 does not Granger cause X_2

$$X_{2(t)} = \sum_{j=1}^{j} a'_{j(t-j)} + \sum_{j=1}^{j} b'_{j(t-j)}$$

$H_o : b'_j = 0 \quad j = 1, 2, \ldots, j$

Lags	Level of Signif.	$M_1 = X_2$: X_2 does not Granger cause X_1	$M_1 = X_2$: X_1 does not Granger cause X_2	$M_2 = X_2$: X_2 does not Granger cause X_1	$M_2 = X_2$: X_1 does not Granger cause X_2
6	5%	$F^6_{82} = 1.79 < 2.18$ critical F^6_{82} Hence: X_2 does not cause X_1.	$F^6_{82} = 3.24 > 2.18$ critical F^6_{82} Hence: X_1 causes X_2.	$F^6_{82} = 3.39 > 2.18$ critical F^6_{82} Hence: X_2 causes X_1.	$F^6_{82} = 2.306 > 2.18$ critical F^6_{82} Hence X_1 causes X_2.
	1%	$F^6_{82} = 1.79 < 2.96$ critical F^6_{82} Hence: X_2 does not cause X_1.	$F^6_{82} = 3.24 > 2.96$ critical F^6_{82} Hence: X_1 causes X_2.	$F^6_{82} = 3.39 > 2.96$ critical F^6_{82} Hence: X_2 causes X_1.	$F^6_{82} = 2.306 < 2.96$ critical F^6_{82} Hence: X_1 does not cause X_2.
8	5%	$F^8_{76} = 1.95 < 2.10$ critical F^8_{76} Hence: X_2 does not cause X_1.	$F^8_{76} = 2.18 > 2.10$ critical F^8_{76} Hence: X_1 causes X_2.	$F^8_{76} = 2.57 > 2.10$ critical F^8_{76} Hence: X_2 causes X_1.	$F^8_{76} = 26.10 > 2.10$ critical F^8_{76} Hence: X_1 causes X_2.
	1%	$F^8_{76} = 1.95 < 2.82$ critical F^8_{76} Hence: X_2 does not cause X_1.	$F^8_{76} = 2.18 < 2.82$ critical F^8_{76} Hence: X_1 does not cause X_2.	$F^8_{76} = 2.57 < 2.82$ critical F^8_{76} Hence: X_2 does not cause X_1.	$F^8_{76} = 26.10 > 2.82$ critical F^8_{76} Hence: X_1 causes X_2.
12	5%	$F^{12}_{64} = 1.82 < 1.92$ critical F^{12}_{64} Hence: X_2 does not cause X_1.	$F^{12}_{64} = 2.65 > 1.92$ critical F^{12}_{64} Hence: X_1 causes X_2.	$F^{12}_{64} = 2.32 > 1.92$ critical F^{12}_{64} Hence: X_2 causes X_1.	$F^{12}_{64} = 1.09 < 1.92$ critical F^{12}_{64} Hence: X_1 does not cause X_2.
	1%	$F^{12}_{64} = 1.82 < 2.50$ critical F^{12}_{64} Hence: X_2 does not cause X_1.	$F^{12}_{64} = 2.65 > 2.50$ critical F^{12}_{64} Hence: X_1 causes X_2.	$F^{12}_{64} = 2.32 < 2.50$ critical F^{12}_{64} Hence: X_2 does not cause X_1.	$F^{12}_{64} = 1.09 < 2.50$ critical F^{12}_{64} Hence: X_1 does not cause X_2.

TABLE 1. Continued.

		Hypothesis	
		X_2 does not Granger cause X_1	X_1 does not Granger cause X_2
		$X_{1(t)} = \sum_{j=1}^{j} a_j X_{1(t-j)} + \sum_{j=1}^{j} b_j X_{2(t-j)}$	$X_{2(t)} = \sum_{j=1}^{j} a'_j{}_{(t-j)} + \sum_{j=1}^{j} b'_j\ (t-j)$
		$H_o : b_j = 0 \quad j = 1, 2, \ldots, j$	$H_o : b'_j = 0 \quad j = 1, 2, \ldots, j$
Lags	Level of Signif.	Base = X_2	
6	5%	$F^6_{82} = 3.22 > 2.18$ critical F^6_{82} Hence: X_2 causes X_1.	$F^6_{82} = 0.65 < 2.18$ critical F^6_{82} Hence: X_1 does not cause X_2.
	1%	$F^6_{82} = 3.22 > 2.96$ critical F^6_{82} Hence: X_2 causes X_1.	$F^6_{82} = 0.65 < 2.96$ critical F^6_{82} Hence: X_1 does not cause X_2.
8	5%	$F^8_{76} = 30.61 > 2.10$ critical F^8_{76} Hence: X_2 causes X_1.	$F^8_{76} = 0.49 < 2.10$ critical F^8_{76} Hence: X_1 does not cause X_2.
	1%	$F^8_{76} = 30.61 > 2.82$ critical F^8_{76} Hence: X_2 causes X_1.	$F^8_{76} = 0.49 < 2.82$ critical F^8_{76} Hence: X_1 does not cause X_2.
12	5%	$F^{12}_{64} = 1.88 < 1.92$ critical F^{12}_{64} Hence: X_2 does not cause X_1.	$F^{12}_{64} = 1.46 < 1.92$ critical F^{12}_{64} Hence: X_1 does not cause X_2.
	1%	$F^{12}_{64} = 1.88 < 2.50$ critical F^{12}_{64} Hence: X_2 does not cause X_1.	$F^{12}_{64} = 1.46 < 2.50$ critical F^{12}_{64} Hence: X_1 does not cause X_2.

On the whole, our results confirm economic theory. The monetary base is truly exogenous with the exception of j = 12. Therefore, our conclusions clearly contradict the results obtained by Sims (1972), found the causality results for M_1 and the monetary base very similar. His study finds GNP purely passive. GNP responds to M (as approximated by both M_1 and monetary base) according to a stable distributed lag, but GNP does not influence M. Our study indicates a considerable difference between M_1 and the monetary base. Although Sims's conclusions are generally applicable to the monetary base, they do not hold true for M_1, which appears to be endogenous in many cases depending on the lag selection and the level of significance. Our results, therefore, appear to support the theoretical arguments concerning the exogeneity of the monetary base and M_1. The results concerning the exogeneity of M_1 and M_2 are, in many cases, similar to the results reported by Hsiao (1981). Using different causality testing procedures, Hsiao reports that changes in M_1 are a consequence as well as a cause of changes in income. When testing different models, Hsiao finds that a bivariate feedback model is best suited for M_1 and GNP, but a one-way causal model performs better for M_2 and GNP[16]. M_2 appears to play a much more independent role in the GNP determination than M_1. On the whole, M_2 is more exogenous than M_1.

It appears that the causality test results for all three test variables are dependent not only on the selection of the level of significance, but, most importantly, they appear to be directly influenced by the lag selection. This point is clearly evident, especially when comparing the monetary base test results. Selecting j = 6 and j = 8, we establish clear unidirectional causality from the base to the GNP. However, when j = 12, the base and the GNP are statistically independent. Therefore, the arbitrary selection of the lag structure can play a crucial role in the causality determination.

IV. Optimal Lag Selection and Model Specification

Hsiao (1981) developed a testing procedure combining a first-stage fitting of unrestricted form with some second-stage hypothesis testing. His procedure involves using five statistical steps for correct system identification[17]. Hsiao's procedure combines the minimum final prediction error (FPE) criterion developed by Akaike (1969a, b) with Granger's (1969) definition of causality. As such, this procedure not only eliminates the arbitrariness in the lag selection but also provides a powerful causality test. According to Akaike (1969a), the estimate of FPEy[Y(m), X(n)] is defined as

$$FPE_y(m, n) = \frac{T + m + n + 1}{T - m - n - 1} \cdot Q_y(m, n)/T \qquad (3)$$

where m and n are numbers of lags on X and Y, T is the number of observations, and Q_y is the sum of the squares of residuals. Using the minimum FPE for the optimal lag determination is equivalent to applying approximate F test with varying levels of significance. However, unlike Akaike's FPE criterion, Hsiao's optimality criterion of minimizing the mean square prediction error avoids the conventional ad hoc selection of 5 percent or 1 percent levels of significance. As such, it completely overcomes the type I and type II errors associated with classical hypothesis testing.

Hsiao uses the following three definitions of causality:

Definition 1. If $\sigma^2(Y/\bar{A}) < \sigma^2(Y/\overline{A-X})$, then X causes Y. This means that in the sense of the mean square error, the prediction of Y using past X is more accurate than not using past X.

Definition 2. If $\sigma^2(Y/\bar{A}) < \sigma^2(Y/\overline{A-X})$, and $\sigma^2(Y/\bar{A}) < \sigma^2(X/\overline{A-Y})$, feedback occurs.

Definition 3. If $\sigma^2[(Y/\bar{A}), \bar{\bar{X}}] < \sigma^2(Y/\bar{A})$, then instantaneous causality of X to Y occurs[18].

In our statistical procedures, we follow Hsiao's method. Using Definition 1, we treat Y as a one-dimensional autoregressive process. The FPE is then computed varying the maximum order of lags from 1 to M. The second step involves treating Y as only output of the system and assuming that X is the manipulated variable controlling the outcome of Y. The FPE criterion is then used to determine the lag order of X, assuming that the order of the lag operator on Y is the one specified in the previous step. The next stage involves comparing the smallest FPEs of steps one and two. If the former is smaller than the latter, then a one-dimensional autoregressive representation for Y is used. If the opposite is true, then X causes Y. Finally, the first three steps are repeated for the X process. Now Y is treated as the manipulated variable.

Our procedures differ in many important respects from Hsiao's. The monetary base is added to M_1 and M_2 as an additional measure of the money stock. All equations are estimated in the natural logarithmic form. The test period under consideration is 1959-I to 1984-II. Finally, we test twelve different lags.

The overall results are illustrated in Tables 2, 3, and 4. Table 5 presents the estimated models. The FPEs obtained from treating each variable as a one-dimensional autoregressive process are reported in Table 2. The smallest FPEs for M_1, M_2, B, and GNP, are 8, 2, 11, and 3. It is then assumed that each of the money and nominal income variables is a

TABLE 2

The FPE of Fitting a One-Dimensional Autoregressive Process for GNP, M_1, M_2, and the Monetary Base (B)

The Order of Lags	FPE of $M_1 \times 10^{-4}$	FPE of $M_2 \times 10^{-4}$	FPE of Bx^{10-4}	FPE of GNP $\times 10^{-4}$
1	0.5249	0.5835	0.2344	1.0486
2	0.5225	0.4216	0.1805	1.0097
3	0.5386	0.4338	0.1818	0.9879
4	0.5245	0.4373	0.1727	1.0181
5	0.5196	0.4409	0.1738	1.0340
6	0.5159	0.4546	0.1694	1.1022
7	0.5287	0.4610	0.1747	1.0455
8	0.5028	0.4614	0.1807	1.0193
9	0.5189	0.4701	0.1825	1.0305
10	0.5309	0.4772	0.1794	1.0510
11	0.5414	0.4259	0.1689	1.0514
12	0.5555	0.4612	0.1746	1.0470

TABLE 3

The Optimum Lags of the Manipulated Variable and the FPE of the Controlled Variable

Controlled Variable	Manipulated Variable	The Optimum Lag of Manipulated Variable	FPE x 10^{-4}
M_1 (8)	GNP	7	0.4649
GNP (3)	M_1	3	0.8945
M_2 (2)	GNP	2	0.4205
GNP (3)	M_2	1	0.8074
B (11)	GNP	1	0.1695
GNP (3)	Base	4	0.8185

TABLE 4

Causality Implications of the FPE Procedure for GNP, M_1, M_2, and Monetary Base

M_1			M_2			Monetary Base (B)		
Process		Implications	Process		Implications	Process		Implications
GNP Process:			GNP Process:			GNP Process:		
FPE (Step 1)	0.9879	0.9879 > 0.8947	FPE (Step 1)	0.9879	0.9879 > 0.8074	FPE (Step 1)	0.9879	0.9879 > 0.8183
FPE (Step 2)	0.8947	M_1 ==> GNP	FPE (Step 2)	0.8074	M_2 ==> GNP	FPE (Step 2)	0.8183	B ==> GNP
M_1 Process:			M_2 Process:			Base Process:		
FPE (Step 1)	0.5028	0.5028 > 0.4649	FPE (Step 1)	0.4216	0.4216 > 0.4205	FPE (Step 1)	0.1689	0.1689 < 0.1695
FPE (Step 2)	0.4649	GNP ==> M_1	FPE (Step 2)	0.4205	GNP ==> M_2	FPE (Step 2)	0.1695	B ==> GNP

TABLE 5

Autoregressive Estimates of GNP, M_1, M_2, and Monetary Base. Dependent Variable is GNP

M_1			M_2			Monetary Base (B)		
Statistics	Lags	Coefficients (t-statistics)	Statistics	Lags	Coefficients (t-statistics)	Statistics	Lags	Coefficients (t-statistics)
R^2 0.999791	ln GNP (-1)	1.099 (10.906)	R^2 0.999804	ln GNP (-1)	1.009 (9.835)	R^2 0.999811	ln GNP (-1)	1.048 (10.222)
S.E. of regression 0.00914	(-2)	-0.094 (-0.625)	S.E. of regression 0.008767	(-2)	-0.137 (-0.969)	S.E. of regression 0.008698	(-2)	-0.129 (0.870)
DW 2.0017	(-3)	-0.010 (-0.100)	F 119704.6	(-3)	-0.026 (0.283)	F 67926.38	(-3)	-0.023 (-0.228)
	ln M_1 (-1)	0.379 (2.752)		ln M_2 (-1)	0.159 (4.832)		ln base (-1)	0.847 (3.813)
	(-2)	-0.019 (-0.0897)					(-2)	-0.731 (-1.890)
	(-3)	-0.356 (-2.475)					(-3)	0.563 (1.454)
							(-4)	-0.551 (-2.414)

controlled variable. The other variable is then treated as the manipulated variable. Selecting the lag structure specified above, we compute the FPEs of the controlled variable by varying the order of lags of the manipulated variable from 1 to 12. The specification which gives the smallest FPE resulting out of this procedure is reported in Table 3. It is clear from Table 3 that the following specifications should be chosen for the test variables:

for M_1 and GNP:

$$\ln GNP = \sum_{\substack{j=1 \\ j=1,\ldots,3}}^{J} aj \ln GNP_{(t-j)} + \sum_{\substack{j=1 \\ j=1,\ldots,3}}^{J} bj \ln M_{1(t-j)}$$

$$\ln M_1 = \sum_{\substack{j=1 \\ j=1,2,\ldots,8}}^{J} aj \ln M_{1(t-j)} + \sum_{\substack{j=1 \\ j=1,2,\ldots,7}}^{J} bj \ln GNP_{(t-j)} \qquad (4)$$

for M_2 and GNP:

$$\ln GNP = \sum_{\substack{j=1 \\ j=1,2,\ldots,3}}^{J} aj \ln GNP_{(t-j)} + \sum_{\substack{j=1 \\ j=1}}^{J} bj \ln M_{2(t-j)}$$

$$\ln M_2 = \sum_{\substack{j=1 \\ j=1,\ldots,2}}^{J} aj \ln M_{2(t-j)} + \sum_{\substack{j=1 \\ j=1,\ldots,2}}^{J} bj \ln GNP_{(t-j)} \qquad (5)$$

for B and GNP:

$$\ln GNP = \sum_{\substack{j=1 \\ j=1,\ldots,3}}^{J} aj \ln GNP_{(t-j)} + \sum_{\substack{j=1 \\ j=1,\ldots,4}}^{J} bj \ln B_{(t-j)}$$

$$\ln B = \sum_{\substack{j=1 \\ j=1,\ldots,11}}^{J} aj \ln B_{(t-j)} + \sum_{\substack{j=1 \\ j=1}}^{J} bj \ln GNP_{(t-j)} \qquad (6)$$

Comparing the results obtained from statistical estimation of equations (4) through (6) with those reported by Hsiao, we find some important differences. Although we confirm Hsiao's results with respect to M_1 and GNP (we also find feedback between M_1 and GNP), our results for M_2 are somewhat different. Our test results indicate that feedback also exists between M_2 and GNP. Consequently, neither M_1 nor M_2 are found empirically truly exogenous. In this sense, the FPE causality estimation procedure yields similar results to those reported for the Granger test in the previous section of this study.

The results reported for the monetary base are of special interest. Using the FPE procedure we find that a one-way causality occurs from the base to the GNP. Consequently, the monetary base is a more appropriate definition of money than either M_1 or M_2. This result not only confirms economic theory, but it also seems to support the findings of the previous section. Clearly, using either the Guilkey and Salemi method of causality testing or the FPE procedure yields identical results with respect to the monetary base. The monetary base is truly exogeneous in the money income relationship.

V. Concluding Remarks

Many causality testing procedures reviewed in this study rely on an arbitrary lag selection process. The results obtained through this method may be unreliable because the distributions of test statistics can theoretically be sensitive to lag length. Using the Granger type causality test procedures outlined by Guilkey and Salemi we find that the test results depend not only on the level of significance under consideration, but even more so they tend to be greatly influenced by the lag selection. Under this procedure, the causality results for M_1 and M_2 are mixed. Neither variable is truly exogenous. The conclusions with respect to the exogeneity, endogeneity, or feedback of M_1 and M_2 appear to be directly dependent upon the arbitrary lag selection. However, even under the arbitrary lag selection, the results for the monetary base are much more conclusive. Setting $j = 6$ and 8, our test results support the hypothesis of inidirectional causality from monetary base to nominal GNP.

Utilizing the FPE procedure outlined by Hsiao, further empirical evidence supports the theory of exogeneity of M_1, M_2, and monetary base. Our test results indicate that feedback exists between both measures of money (M_1 and M_2) and nominal GNP. When the monetary base is used as the measure of money, then a direct causal relationship between monetary base and nominal GNP exists. This result supports the findings of the previous section.

The findings indicate that the monetary base is a better instrument for controlling nominal income because of unidirectional causal flow from base to nominal income. This conclusion is supported by evidence outlined in sections III and IV of this study.

Footnotes

1. The origins of the exogeneity of money debate can be traced to the 18th century Bullionist controversy and the Currency-Banking School debate of the 19th century. For a further discussion of these issues, see Humphrey (1974), Makinen (1977), Becker and Baumol (1952), and others.

2. Earlier writings on this subject can be found, among others, in the Radcliffe Report (1959) and in Gurley's (1960) paper.

3. For a further explanation of this view see Gramley and Chase (1965), Kareken (1967), Davis (1968), and others.

4. Adam Smith first formulated the Real Bills Doctrine, which stated that as long as bank lending was restricted to self-liquidating commercial paper based upon goods and services, the amount of money could never be overissued. Hence, the stock of money was endogenously determined.

5. For a thorough theoretical discussion of these views, see Friedman (1970, 1972), Tobin (1972), Patinkin (1972), and many others.

6. For a further discussion of this view and some empirical evidence, see Andersen (1968).

7. A more detailed discussion of this view can be found in Friedman and Schwartz's (1963) work.

8. It can conceivably be argued that even the monetary base is not entirely exogenous, since borrowed reserves and cash in the hands of the public are outside of the Fed's control (see DeLeeuw and Kalchbrenner (1969)). For a further discussion of the exogeneity issue and empirical evidence, see Cagan (1965), Brunner and Meltzer (1964), Fand (1970), and others.

9. For a further discussion of these components, see Siegel (1982, pp. 135-144).

10. The Sims test requires OLS estimation of the following equation:

$$X_{1(t)} = \alpha + \sum_{j=-LF}^{LL} ajX_{2(t-j)} + U_t ,$$

where X_1 is the nominal GNP, and X_2 is the money stock (either M_1 or M_2). The test of the null hypothesis that X_1 does not cause X_2 is the test that $aj = 0$ for $j = -1, -2, \ldots, -LF$.

11. For exact specification of these tests, see Guilkey and Salemi (1982, pp. 669-670).

12. For a theoretical explanation of the procedure for system identification, see Hsiao (1981, pp. 87-93).

13. Hsiao (1981, pp. 99-100) gives a detailed description of these results.

14. It is demonstrated in the following part of our study that varying the lag structure can lead to different causality implications.

15. All the data used in our study are seasonally adjusted at the source. However, the lag distributions used in our study are long enough to prevent any bias from the source to seriously affect the test results. For a further discussion of this point, see Sims (1972, p. 546).

16. For a further explanation of this point, see Hsiao (1981, pp. 104-105).

17. For the exact outline of each of these steps, see Hsiao (1981, pp. 92-93).

18. Hsiao (1981, pp. 90-91) gives his definitions of causality.

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